

# **Exhibit F**

**EXPERT REPORT OF JONATHAN RODDEN, Ph.D.**

***Carter v. Chapman*, 464 MD 2021, 465 MD 2021 (Pa. Commw. Ct.)  
January 26, 2022**

In this report, I provide a brief analysis of a set of 13 Pennsylvania congressional redistricting plans that were provided to me on January 24. I have been asked to provide a basic analysis of these plans, and to compare them with a redistricting plan, called the “Carter Plan,” that I submitted in this case on January 24. Please see my previous report for a discussion of my qualifications and relevant experience.

First, I assess the extent to which these plans place voters in different districts than those of the 2018 Remedial Plan ordered by the Pennsylvania Supreme Court four years ago. Second, I assess these plans according to several traditional redistricting criteria, including population equality, contiguity, compactness, and splits of counties, county subdivisions, and vote tabulation districts. Third, I assess the likely partisan outcomes associated with these plans.

**I. DEVIATION FROM THE PREVIOUS REDISTRICTING PLAN**

In the expert report I submitted in this case on January 24, I explained that the Carter Plan was explicitly crafted to minimize the changes from the 2018 Remedial Plan, which had only been in place for two elections. This choice was made because the Pennsylvania Supreme Court had very recently endorsed this plan as meeting all its objective criteria.

I measured the extent to which each of the submitted plans places voters in the same district as in the previous 2018 plan. Note that some district numbers have changed. For each district in each submitted plan, the task is to find the overlapping fragments of districts from the previous plan and identify the largest one. I then calculate the share of all voters in the proposed new district living in that largest fragment. For instance, since Bucks County is in the corner of the state and has a population relatively close to the required population for a congressional district, most map-drawers drew a district that was dominated by Bucks County, adding in some municipalities on the Western or Southern edge of the district in Montgomery or Philadelphia, just as the previous plan had done. For this Bucks County-oriented district, many of the plans had what I will call a “retained population share” of over 90 percent. However, as explained in my earlier report, these shares were necessarily much lower in Central Pennsylvania in all the plans, because rural population loss required more substantial changes.

Some of the plans also introduced major changes in metro areas. For instance, while the 2018 Remedial Plan kept the city of Pittsburgh whole, some plans, including the Governor’s plan, opted to split it. The plan introduced in HB2146 pursues a different orientation of the Pittsburgh area altogether, adding a number of more rural, Republican communities to what was previously a very competitive but Republican-leaning district.

I have calculated the average “retained population share” across all the districts in each plan, and I report this quantity in Table 1.

**Table 1: Retained Population Share in 14 Submitted PA Congressional Plans**

<b>Plan</b>	<b>Retained Population Share</b>
<b>Carter</b>	<b>86.6</b>
CCFD	76.1
Citizen Voters	82.4
HB2146	78.5
Draw the Lines PA	78.8
GMS	72.8
Governor Wolf	81.2
Ali	81.5
PA House Dem. Caucus	73.3
Reschenthaler 1	76.5
Reschenthaler 2	76.5
Senate Dem. Plan 1	72.5
Senate Dem. Plan 2	72.5
Voters of PA	80.6

Not surprisingly, since the Carter Plan explicitly set out to minimize boundary changes, its districts retain more of their former population—around 87 percent—than any of the submitted plans. The plans that make the largest changes are the Senate Democratic plans, the GMS plan, and the House Democratic Caucus plan.

## **II. TRADITIONAL REDISTRICTING CRITERIA**

### ***Population Equality***

The ideal population for a Pennsylvania Congressional District in the 2022 round of redistricting is 764,865. Each of the maps, including the Carter Plan, creates 17 districts where the population, according to the 2020 Census, is either precisely that number, one more, or one less. The only exception is the map submitted by Khalif Ali, where the districts were drawn using the Legislative Reapportionment Commission’s Data Set #2, which contains population adjustments to account for the reallocation of most prisoners to their last known address prior to incarceration. When analyzed using the Census data or Legislative Reapportionment Commission’s Data Set #1, the Ali map results in districts that have population deviations of up to several thousand people. But it purports to be equally populated under Data Set #2, and I did not analyze its population equality under that data set.

Given ongoing residential moves, measurement error, and the efforts of the census department to protect privacy, deviations of zero or a single voter from “perfect” equality are a form of what is commonly referred to as “false precision.” Given measurement error and population churn, even plans with zero population deviation in every district are unlikely to be *truly* equal in population.

The best we can say is that in each of these plans, populations are as close to equal as is possible given the constraints of the data.

### ***Contiguity***

Each of the maps, including the Carter Plan, has districts made up of contiguous territory. The only potential exception is the CCFD map, which includes a zero-population noncontiguous census block in District 9.

### ***Compactness***

All the maps I received include relatively compact districts. There is no widely accepted “best” measure of compactness, and each measure achieves something different. Two measures of compactness often considered by courts are the Polsby-Popper score and the Reock score. The Polsby-Popper score is the ratio of the area of the district to the area of a circle whose circumference is equal to the perimeter of the district. This score rewards districts with smooth perimeters and penalizes those with more contorted borders. To the extent that jagged borders are sometimes caused by natural features, like rivers separating counties, coastlines, or boundaries of cities that have experienced odd-shaped annexations over the years, the Polsby-Popper score might serve as a rather poor indicator of political manipulation. If one map-drawer chooses to keep an odd-shaped city whole, and another elects to split the city cleanly down the middle, the first map-drawer will end up with a district with a lower Polsby-Popper score. Likewise, if one district-drawer chooses to keep a county whole—but the county’s boundary is a meandering river—this district will have a lower Polsby-Popper score than that of another district-drawer who chooses to split the county along a smooth municipal boundary.

The Reock score is computed by dividing the area of the district by the area of the smallest circle that would completely enclose it. The downside of this measure is that it can be sensitive to the orientations of a district’s extremities. A rather odd-shaped district, for example one resembling a coiled snake, might still end up with a low Reock score if it stays nicely within the bounding circle. Fortunately, the districts submitted to the Court are not rife with such odd-shaped districts.

In general, the compactness scores all fall within a relatively narrow range. None of the submitted plans features highly non-compact districts with tentacles, claws, and the like.

### ***Splits of Jurisdictions***

Some maps- are more successful than others in keeping political subdivisions whole. Table 1 provides information about county splits in the submitted plans. It makes a subtle distinction between the number of split counties and the total number of county splits. The number of split counties is, quite simply, the number of counties that were not kept whole, regardless of how many splits they experienced. However, some counties were split multiple times. Many of the maps, for instance, split Philadelphia, Montgomery, or Berks County among three rather than just two districts. And some of the plans extracted separate chunks of the same county in different regions of the county. The last column in Table 1 adds up the *total* number of splits, such that a county

split between three districts counts as two splits rather than one, and two non-contiguous splits of the same county are both counted.

**Table 2:**  
**County Splits in 14 Submitted Congressional Plans**

<b>Plan</b>	<b>Number of Split Counties</b>	<b>Total County Splits</b>
<b>Carter</b>	<b>14</b>	<b>17</b>
CCFD	16	20
Citizen Voters	14	17
HB2146	15	20
Draw the Lines PA	14	18
GMS	15	19
Governor Wolf	16	22
Ali	16	20
PA House Dem. Caucus	16	18
Resenthaler 1	13	18
Resenthaler 2	13	18
Senate Dem. Plan 1	17	20
Senate Dem. Plan 2	16	18
Voters of PA	15	17

The two Resenthaler plans split 13 counties, while the Carter, Citizen Voters, and Draw the Lines PA plans split 14. Note that in my previous report, I adopted the Pennsylvania Supreme Court’s logic, arguing that the Carter Plan’s split of only 6 people in order to preserve contiguity while avoiding a split of Chester County should not be counted, and the true number of split counties in the Carter Plan is actually 13 instead of 14. However, since I have not had the opportunity to assess such technicalities in each of the 13 other plans, Table 2 counts even these tiniest splits wherever they occur. The largest number of split counties, 17, is found in Senate Democratic Plan 1. However, if we focus on *total* splits, the Carter Plan, Citizen Voters Plan, and Voters of PA plans demonstrate the lowest number of splits, 17, and the Governor’s Plan demonstrates the largest number of splits, 22.

One might imagine that a low number of split counties goes hand in hand with higher levels of compactness, but for reasons described above, this is not necessarily the case. Figure 1 plots the Reock Score against the total number of county splits in each plan. There is only a weak negative relationship. Figure 1 shows that the “Voters of Pennsylvania” plan and the Carter Plan are the most compact, according to the Reock Score, and have the lowest number of total county splits.

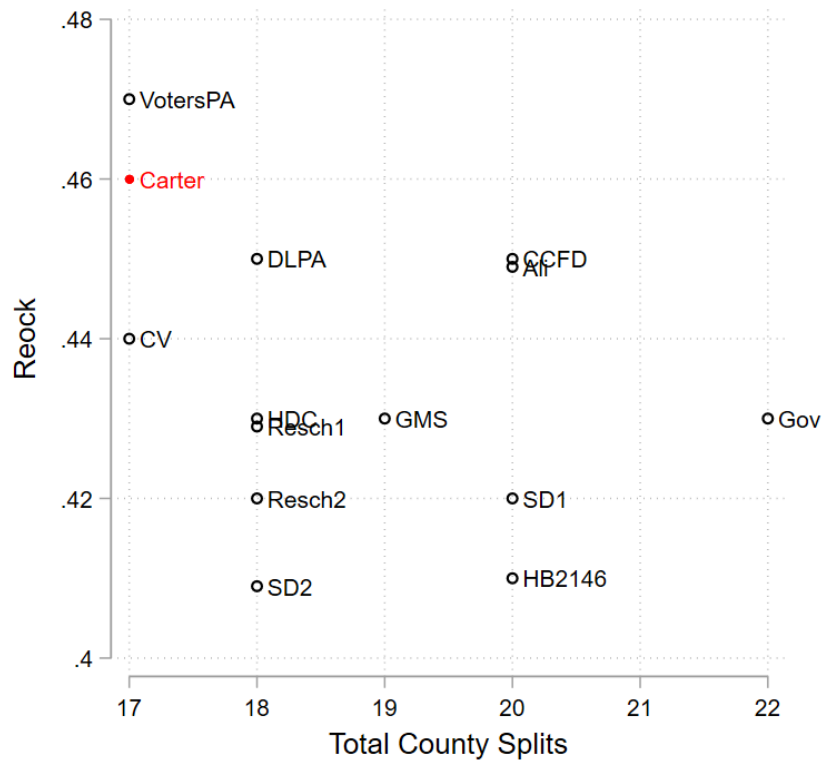
**Figure 1: Reock Compactness Score and Total County Splits, 14 Submitted Plans**

Table 3 examines splits in the boundaries of County subdivisions, using geo-spatial boundaries curated by the U.S. Census Department. The Carter Plan splits 20 such subdivisions, while the lowest number of subdivisions splits is demonstrated by the CCFD Plan, with 14. When it comes to *total* County Subdivision splits, the Carter Plan is in the middle of the distribution across plans.

**Table 3: County Subdivision Splits in 14 Submitted Congressional Plans**

Plan	Number of Split County Subdivisions	Total County Subdivision Splits
Carter	20	23
CCFD	14	18
Citizen Voters	16	21
HB2146	16	25
Draw the Lines PA	16	23
GMS	16	26
Governor Wolf	17	35
Ali	18	24
PA House Dem. Caucus	18	20
Resenthaler 1	15	22
Resenthaler 2	15	22
Senate Dem. Plan 1	19	22
Senate Dem. Plan 2	16	18
Voters of PA	18	26

In the world of election administration, it is especially useful to avoid splitting vote tabulation districts (VTDs). Above all, split VTDs can lead to mistakes for local election administrators, who must be sure to provide the right ballot for residents living in two different political districts, even though they might be voting at the same polling place. However, when a redistricting plan is aiming to seek population equality within a very narrow allowable deviation, like plus or minus one person, it is often not possible to avoid splitting a VTD somewhere along the boundary of two districts, since the VTD populations simply do not add to precisely the right numbers. Nevertheless, it is possible to minimize these splits. Table 4 provides the number of VTDs that were split by each plan.

**Table 4: Split Vote Tabulation Districts in 14 Submitted PA Congressional Plans**

<b>Plan</b>	<b>Number of Split VTDs</b>
<b>Carter</b>	<b>14</b>
CCFD	16
Citizen Voters	26
HB2146	9
Draw the Lines PA	23
GMS	17
Governor Wolf	17
Ali	27
PA House Dem. Caucus	16
Resenthaler 1	31
Resenthaler 2	31
Senate Dem. Plan 1	16
Senate Dem. Plan 2	16
Voters of PA	16

The two plans with the lowest number of split VTDs are HB2146 and the Carter Plan. The plans with the most split VTDs are the Resenthaler plans and the Ali Plan.

### **III. PARTISAN FAIRNESS AND COMPETITION**

A final task is to assess whether the plans are fair to both political parties. As explained in my initial report submitted in this case, if we look at statewide elections in recent years, around 52 to 53 percent of votes for the two major parties go to Democrats. The 2018 Remedial Plan had 18 districts, and the Congressional delegation was evenly split, 9 to 9. Given the overall statewide vote share, this map gave a slight advantage in practice to the Republican Party, though as pointed out in my earlier report, it is important not to be misled by simple seat counts without a closer look at the underlying partisanship of districts and the role of incumbency. Several districts in the previous plan were relatively balanced, both in terms of statewide partisanship and actual congressional elections, and one district—District 1 in Bucks County—leaned toward Democratic candidates in statewide races but consistently elected a Republican Congressional representative.

Now there is an odd number of districts, so a tied delegation is no longer possible. Given the Democrats' advantage in the statewide vote share, one would anticipate that the Democratic Party would be able to win a majority of congressional seats as well, especially since, as detailed in my previous report, population has been declining in Republican areas and increasing in Democratic areas, with Democratic support also *growing* in the areas that are gaining population.

As I have described elsewhere,<sup>1</sup> Pennsylvania's political geography is such that at the scale of congressional districts, Democratic and Republican areas are in sufficient proximity to one another—above all, along the Eastern side of the state and in the Pittsburgh suburbs—that it should also be possible to sustain some competitive districts that will change hands between the parties as voters' preferences change.

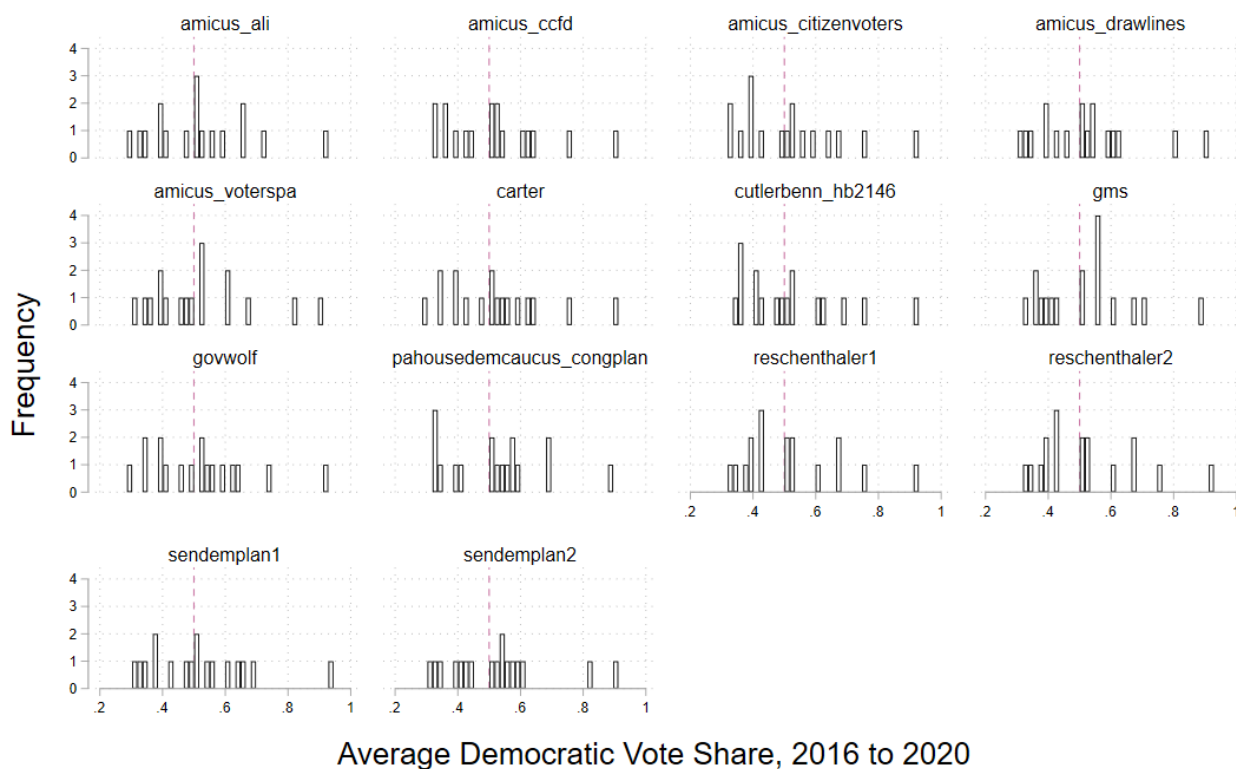
To examine partisanship, as in my previous report, I have aggregated the precinct-level votes for the two parties in all the statewide elections from 2016 to 2020 and calculated the average share of the vote for each of the two major parties in each district. A good way to visualize the result of this exercise is with Figure 2, which provides histograms of the Democratic vote share across districts for each plan. The 50 percent point is indicated with a dashed red line. On the left-hand side of the line are districts that Republicans can anticipate winning, and on the right-hand side are the districts that Democrats can expect to win. When the bars are higher, this indicates that there are multiple districts in that bin. The height of the bin corresponds to the number of districts in that bin. For instance, we can see that the Ali Plan has three districts that are very close to evenly divided between the parties. We also can see that all the plans have exceptionally Democratic districts on the right-hand side of the graph because most of them keep the very Democratic neighborhoods of Philadelphia together.

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<sup>1</sup> Jonathan Rodden, *Why Cities Lose: The Deep Roots of the Urban-Rural Political Divide*. New York: Basic Books.



**Figure 2:**  
**The Distribution of Partisanship Across Districts of 14 Submitted Congressional Plans**



Graphs by plan

One way to use the data in Figure 2 is to simply add up the districts that are on either side of the red line. How many districts have Democratic majorities in these statewide races, however small, and how many have Republican majorities?

If we are interested in competitive districts, we can also ask how many seats are in the bins closest to the red lines in Figure 2. I have calculated the number of seats in each plan between 50 percent Democratic and 52 percent Democratic, and those between 50 percent Republican and 52 percent Republican, using statewide elections from 2016 to 2020. This information is set forth in Table 5 below.

**Table 5: Number of Seats in Various Categories, 14 Submitted Congressional Plans**

Plan	# of seats with statewide Dem vote share >.5	# of seats with statewide Dem vote share >.52	# of seats with statewide Dem vote share between .5 and .52	# of seats with statewide Rep vote share between .5 and .52	# of seats with statewide Rep vote share >.52	# of seats with statewide Dem vote share >.5
Ali	10	7	3	0	7	7
CCFD	10	8	2	0	7	7
Citizen Voters	9	8	1	1	7	8
Draw the Lines PA	10	8	2	0	7	7
Voters of PA	8	8	0	2	7	9
Carter	10	8	2	0	7	7
HB2146	8	7	1	2	7	9
GMS	10	8	2	0	7	7
Governor Wolf	9	9	0	1	7	8
PA House Dem. Caucus	11	9	2	0	6	6
Reschenthaler 1	9	6	3	0	8	8
Reschenthaler 2	9	7	2	0	8	8
Senate Dem. Plan 1	9	7	2	1	7	8
Senate Dem. Plan 2	10	9	1	0	7	7

In most of the plans, either 9 or 10 seats have average Democratic vote shares above 50 percent (see the first column in Table 5). However, one can look at Figure 2 above, or at the middle columns in Table 5, to see that typically, anywhere from one to three of the nominally Democratic districts are very close to 50 percent. In the Carter Plan, two of the Democratic-leaning districts, as determined by statewide elections, are in this category. These are usually in the Lehigh Valley, the Northeast, and/or suburban Pittsburgh. In other words, by no means does this analysis tell us the Democrats will win 10 seats in, for instance, the GMS plan. Figure 2 and Table 5 tell us that two of the districts in this plan are essentially toss-ups based on the statewide data.

In the Carter Plan, there are 10 Democratic-leaning districts, but two of them are very close to toss-ups, yet there are no Republican-leaning toss-ups. Thus, based purely on statewide election data, the Carter Plan could easily lead to a 9-8 Republican majority.

However, as I explained in my earlier report, the statewide analysis in Table 5 is potentially quite flawed. I pointed out that the Republican incumbent in Bucks County, Brian Fitzpatrick, typically outperforms his party by over 7 percentage points. As mentioned above, the Bucks County district experiences very little change in all these plans. As a result, all these plans include a district with a statewide Democratic vote share above 50 percent where the Republican incumbent is very likely to win. In fact, in many of these plans, including the Carter Plan, Table 5 categorizes the district

in which Rep. Fitzpatrick wins by large margins as a relatively comfortable *Republican* district. In other words, if the goal of the first column of Table 5 is to predict Democratic wins, one seat should be moved from the far-left Democratic column in Table 5 to the far-right Republican column.. The anticipated number of Democratic seats in the Carter Plan, for example, is 9, not 10 if we consider this important fact.

Three plans are outliers: First, HB2146 and the “Voters of PA” plan both produce a minority of Democratic-leaning seats in spite of the Democrats’ overall statewide majorities during this period. This is especially noteworthy if we account for the incumbent in the Bucks County-based district and recognize that these plans are likely to produce only 7 Democratic seats (i.e. 41 percent of the seats in a state where Democrats get more than 52 percent of the vote).

The Reschenthaler 1 and Reschenthaler 2 plans also stand out, in that they produce 8 comfortable Republican seats, not including Rep. Fitzpatrick’s seat, and an unusually low number of comfortable Democratic seats, achieving a nominal, and potentially misleading, total of 9 Democratic-leaning seats by producing either 2 or 3 toss-up seats that lean Democratic.

The Senate Democratic Plan Number 1, too, produces fewer comfortable Democratic seats than almost every other plan.

In the other direction, the Pennsylvania House Democratic Caucus is an outlier in that it is the only plan with 11 seats above the 50 percent Democratic threshold. Governor Wolf’s Plan, as well as the Senate Democratic Plan Number 2 are unusual in that they produce only 1 district in the 50 to 52 percent range for either political party.

The HB2146 and “Voters of PA” plans, as well as the Reschenthaler plans, also stand out in another respect. Using the 2016 to 2020 statewide average, I have calculated the mean Democratic vote share across all the districts in each plan, as well as the median Democratic vote share in each plan. The mean and median are almost identical in all the plans, with the exception of these three. In HB2146, the average Democratic vote share is higher by 2.4 percentage points than the median Democratic vote share. In the “Voters of PA” plan, it is higher by 2.6 percentage points. In the Reschenthaler plans, the difference is 1 percentage point. This simple statistic captures the fact—also evident in Figure 2 above, that the distribution of Democratic vote shares across districts is unusually skewed in these plans. Democrats are quite concentrated in districts that they win with large majorities, in the right tail of the distributions depicted in Figure 2, and there is a large density of districts that Republicans win by comfortable, but not overwhelming, majorities, to the left of the red lines in Figure 2. This results in a mean Democratic vote share that is higher than the median. We do not see a similar skew in the cross-district distributions for any of the other plans.

**Table 6: Mean-Median Difference for 14 Submitted Congressional Plans.**

<b>Plan</b>	<b>Mean Median Difference</b>
Ali	0.004
Carter	0.005
CCFD	0.005
Citizen Voters	0.014
Draw the lines	0.006
GMS	0.005
Gov. Wolf	0.006
HB2146	0.024
HDC	0.004
Resenthaler 1	0.01
Resenthaler 2	0.01
Sen Dems 1	0.007
Sen Dems 2	0.007
Voters of PA	0.026

#### **IV. CONCLUSION**

The 14 plans reviewed in this report are in a relatively narrow band when it comes to population equality, county, county subdivision, and vote tabulation district splits, as well as compactness. The Carter Plan was more faithful than the others to the original 2018 districts and preserved more of the population of these districts within the proposed new districts. It also ranks at or near the top of the plans in terms of county and VTD splits, and the Reock compactness score.

Most of the plans produce either 9 or 10 districts in which Democratic statewide candidates have received majorities in recent years. The Carter Plan produces 10. It should be noted, however, that in most of these plans, including the Carter Plan, one of those districts is quite likely to be won by a Republican incumbent, so that the most likely outcome is 8 or 9 Democratic members of Congress. Two plans, the HB2146 plan and the “Voters of PA” Plan, are clearly more favorable to Republican candidates, and would likely lead to counter-majoritarian outcomes. Another plan, produced by the House Democratic Caucus, is unusually advantageous to the Democratic Party.

Ultimately, when one considers only those plans that accurately reflect Pennsylvanians’ statewide voter preferences, then the Carter Plan does best (or ties for best) on the Reock compactness score, county splits, and VTD splits and retains the most voters in their 2018 districts.

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I hereby certify that the foregoing statements are true and correct to the best of my knowledge, information, and belief. This verification is made subject to the penalties of 18 Pa.C.S. § 4904 relating to unsworn falsification to authorities.



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Jonathan Rodden

January 26, 2022